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The effect of distribution of rewards, grade level and achievement level on small group applicational problem solving.

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THE EFFECT OF
DISTRIBUTION OF REWARDS, GRADE LEVEL AND
ACHIEVEMENT LEVEL
ON
SMALL GROUP APPLICATIONAL PROBLEM SOLVING

A Dissertation Presented

By

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In surveying the recent small group-individual literature three major classes of variables emerge. Studies vary due to task dimensions, group dimensions and Ss dimensions. Therefore, the purpose of this study will be threefold. First, an attempt will be made to construct a task corresponding to the optimal task conditions for group facilitation, and to compare group and individual performance on such a task. Secondly, concerning group dimensions, there will be some redefinition and clarification of the group variables currently considered under the concepts of cooperation and competition. This redefinition will then be related to group cohesion and pressures toward conformity in addition to individual performance. Finally, the Ss variables of grade level and ability level will be examined in relation to the preceding experimental conditions.

Does small group discussion facilitate individual learning? Numerous studies and reviews (Lorge et al, 1958; Kelley and Thibaut, 1954; Secord and Backman, 1965; Shaw, 1932; Hall, Morton and Blake, 1963; and others) have dealt with this subject and quite frequently have concluded that group performance is superior to individual performance under certain specified conditions. Bales (cited in Kelley and Thibaut, 1954) goes as far as to suggest that group problem solving is the model for individual problem solving, and that the individual acquires problem solving skills only by the practice of analysis, synthesis and evaluation as experienced in group performance. However, the empirical evidence is still highly qualified and contradictory.

In fact, one of the striking phenomena of group-individual research taken as a whole, is its remarkable lack of consistency across experimental conditions. The superiority of group vs. individual productivity depends on at least three major types of factors--namely, task factors, type of group factors and Ss factors. Each of these classes of factors must be given adequate consideration as either a control or a variable in small group studies.

Task dimensions.

Meaningful task dimensions have long been ignored in group-individual performance studies. In fact, much of the research on group performance has been done using inconsequential problems such as anagrams, puzzles, games such as twenty questions, with divergent results and little generalizability to possible application (Lorge et al, 1958; Davis, 1966). Recently several authors have emphasized one of two specific relevant task dimensions. The first of these dimensions refers to a continuum of task interdependence. Breer and Locke (1965) define this continuum in a study exclusively concerned with the effects of different task demands. Their classification refers to the collective vs. the individualistic task. A "collective" task can be defined as one in which a pooling of individuals' resources or a division of labor for a common product is the most efficient strategy for success. An "individualistic" task refers then, to a tank which can be completed by individuals working alone on separate units with greater efficiency than by a combined effort. A somewhat similar distinction is made by Thibaut and Kelley (1959) when they refer to conjunctive and disjunctive tasks; by Miller and Hamblin (1963) in reference to the "means interdependence" of a task, and by Thomas (1957) using the term "role interdependence". The distinction in all of these terms is the degree of possible division of labor and coordination of resources as opposed to duplication of effort. Logically, tasks can be defined as nearer one end of the continuum than the other. Thus Deutsch's (1949) cooperative discussion problem is considered to be of high interdependence and Phil p's (1940) transfering-marbles-to-a-box task of low interdependence.

Empirically the two kinds of tasks near either end of the continuum have distinctly different results. Group variables designed to increase the intra-group cooperation have consistently facilitated performance in the high interdependent task and have a neutral or negative effect on the low interdependent tasks. (Miller and Hamblin, 1963-review of 24 studies; Thomas, 1957).

A second task dimension of relative importance concerns task difficulty level or complexity. In general, group discussion facilitates individual learning more when the task is of moderate difficulty level. (Lott and Lott, 1966). According to Shaw (1932) a major reason for group superiority is rejection of incorrect solutions. This process is only possible when items are of moderate difficulty.

Considering these two variables of task interdependence and task complexity, it seems possible to construct meaningful tasks which are of moderate interdependence and of moderate complexity. Such tasks would provide a more nearly predictable test for group variables.

A potential task area involves the educational concept of problem solving, particularly applicational problem solving. Bloom

(1964) defines applicational problem solving as that behavior which involves selection of appropriate facts and principles, evaluating their relevance to a new set of circumstances, and using such facts and principles to reach a solution to the new circumstances. This is to be contrasted with the amorphous collection of items (puzzles, anagrams, transfering marbles, etc.) currently referred to as problem solving in the psychological literature. (Davis, 1966). Bloom's types of applicational problem solving behavior has frequently been cited as an important educational aim and yet it is considered a difficult type of behavior to elicit. (Dressel and Nelson, 1956 and others). Furthermore, while there is considerable research on the relatively simple learning behavior of acquisition of facts and principles, comparatively few studies have dealt with the more complex behavior involved in applicational problem solving. Yet this is just the type of task which is optimal in small group studies. Applicational problem solving items can be constructed of moderate complexity, and theoretically have the potential for moderate interdependence. Group discussion of such problems involve several roles--presentation of opinions concerning relevant facts, clarification and justification of appropriateness, rejection of errors, etc.

Therefore, it is proposed that applicational problems, specifically science applicational problems, can readily meet the criteria of a realistic and meaningful task, of moderate potential interdependence and which can be constructed to be of moderate difficulty level. Such task items will be pretested on a population of individual Ss and those items which are empirically determined to be of moderate difficulty will constitute the final experimental task.

Distribution of rewards.

A second important sector of small group variables concerns type of group factors. The area of cooperation-competition is of particular concern. However, the whole area of cooperation-competition needs further examination. To begin with, cooperation and competition when operationalized is usually not a unitary concept as several authors have noted. (Murphy, Murphy and Newcomb, 1937; May and Doeb, 1937; Miller and Hamblin, 1963; Thomas, 1957; Phillips and Devault, 1957). To illustrate the difficulties in operational definition it is necessary first, to go back to the classic Deutsch (1949) theoretical definition. Deutsch defined a cooperative social situation as one in which members of the group have "promotively interdependent goals". Groups have promotively interdependent goals when a "goal region can be entered... by any given individual or subunit only if all the individuals or subunits under consideration can also enter their respective goal regions." Similarly a competitive social situation exists when there are "contriently interdependent goals" or in "a goal region is entered by any individual...the other individuals or subunits will be (to some degree) unable to reach their respective goals." These two conditions, conceived as end points on a continuum were found by Deutsch to have differential effects on group performance, the process of group functioning and the cohesiveness of the group. However, cooperation, more than competition, is very difficult to operationalize without 1) losing some of the meaning of cooperation or 2) confounding 2 or 3 antecedent variables into a global concept of cooperation.

First, cooperation is frequently induced by inter-group competition. However, competition is not necessarily implied in the definition of "promotively interdependent goals." Indeed, in intergroup competition one could say that the individual has simultaneously a situation of "promotively interdependent goals," with respect to his own team and of "contriently interdependent goals" with respect to other teams. This was contrasted with the competitive condition of intra-group competition, in which the individual was faced with a less complex situation of simply "contriently interdependent goals." To use the label <u>cooperative</u> for this definition is definitely misleading. It is probably more precise to label this study and others like it, as studies in the differential <u>distribution of rewards</u> if they are concerned with inter- and intra-group competition toward some desired goal. Although the preceding definition of cooperation as distribution of rewards seems to lack some of the broader meaning of "promotively interdependent goals," it is actually preferable to the following two types of confounded definitions.

One type of definition involves the confounding of the absolute level of incentive along with the distribution of rewards. For example, some investigators (Phillips, 1956) define competition as intra-group rivalry and cooperation as simply the absence of intra-group rivalry. Thus the competitive group not only has the goal of reaching some desired end (i.e. completion of the problem, a "well done" group mural, etc.) but they have the added incentive of a prize for the first (or best) member. The cooperative group lacks such an added incentive. It is clear that the competition condition in this type of experiment involves not only the differential distribution of rewards but also the mere presence of a reward that is not given in the comparison group. The superiority of competitive over cooperative conditions in this type of study could be explained by the increased incentive alone.

A second confounding problem in operational definition concerns the operational procedures which change the nature of the task between the cooperative and the competitive conditions so that they are no longer comparable. For example, Deutsch's (1949) cooperative groups were to be judged on the basis of the quality of an integrated group product. His competitive groups were told that they were to be judged on the oral contribution of each member to the group's discussion prior to the construction of the final product--a product vs. a process goal. Similarly, Phillips' (1956) competitive Ss were rewarded for individual rapid insightful answers while his cooperative Ss received no such reward for guessing behavior. It can be seen that this change in task is usually reflected on the dimension of task interdependence, with the cooperative task often being more interdependent than the competitive task. But as we have previously mentioned there is an interaction between interdependent goals or distribution of rewards and task interdependence. (Miller and Hamblin, 1963; Thomas, 1957). Cooperative goal interdependence is superior to competitive incentives when the task is an interdependent one, such as human relations problems requiring a group decision. When there is low task interdependence, the effect of goal interdependence is unclear, generally with competitive motivation slightly higher. To confound the two factors would then increase the difference between the two conditions.

Considering this confusion of definition, in this study the term distribution of reward will be used to refer to the intra- and inter-group competition as well as individualistic competitive conditions. The degree of incentives will remain constant with one out of every three Ss receiving a reward. Only distribution of rewards between specific individuals will vary.

Specifically, three distinct experimental conditions will be compared. In the equal distribution reward condition (or inter-group competition) all three interacting members of the same team will receive an equal reward in competition with 2 other teams. In the differential distribution of rewards condition (or intra-group competition) only one member of each three member interacting team will be rewarded. In the individualistic condition (a control for small group processes) all Ss will work alone with a ratio of one in three Ss being rewarded in each experimental session.

One further consideration concerning the distribution of rewards involves how this variable is hypothesized to affect productivity. Lott and Lott (1965) in their review of cohesion as defined as "interpersonal attraction" generally find that cooperative instructions are antecedents of increased cohesion. Using a variety of measures, Stendler, Damrin, and Haines (1951) with second grade children, and Phillips and D'Amico (1956) with fourth-grade children, and Gottheil (1955) working with eight-grade students, as well as several adult studies, all found increased attraction as a result of cooperating on a task with a shared reward. Furthermore, cohesion has generally but not always facilitated group productivity. (Lott and Lott, 1965). In addition, there is generally a positive relation between cohesion and a consequent uniformity of opinion (Lott and Lott, 1965). If this assumption is correct, one might conclude that one could induce cohesion and pressures toward conformity by equivalent rather than differential reward instructions, and by group performance rather than individual performance. An increase problem solving performance would be accomplished by an increase in cohesion and pressures toward conformity indices. In order to test this hypothesis, this study will take concurrent measures of cohesion as measured by a group atmosphere scale and of pressure toward conformity by the amount of consensus within each discussion group.

Subject variables.

Considerable variation in the results of small group studies occur with the use of different Ss populations. Indeed, frequently reviewers (Lorge, 1958; Phillips and De Vault, 1957; Roseborough, 1953; May and Doob, 1937) have mentioned the potential sources of variation as differences in cohesion, cooperative norms, style of responding, etc. For example, Fiedler's (1953) study, using plane crews, an unusually cohesive population, indicates that contrary to the usual cohesion and productivity studies, those crews showing the highest degree of "psychological closeness" were less productive than the lower level cohesive groups. It might be further hypothesized that the frequently used college student population is an unusually competitive population. Although it has frequently been suggested that a use of grade school children would provide a broader population as well as a developmental perspective, relatively few studies using children have been found in the literature. Furthermore, many of these studies using children were done before the widespread use of adequate statistical techniques, thus leaving the conclusions uncertain. In this study the two Ss variables of grade-age level and achievement level will be specifically manipulated.

Grade-age level.

The age of the Ss in group problem solving affects not only the problem solving ability, but the social, motivational characteristics of the individuals in small group interaction. It might be assumed that the problem solving ability would be gradual and continuous and more related to cognitive development. Group interaction process in heterosexual groups might be fluctuating and more dependent on temporary social and physical maturation factors. Therefore, the early adolescent period, specifically the seventh and eighth grade will be selected to examine these two factors. It might be assumed that the cognitive development between these two grades would be minimal, offering perhaps similar problem solving ability. However, since the spring of the seventh grade is a period of maximal difference between male and female maturation and the incumbent social distance between the sexes, it would be expected that the seventh grade (in comparison with the eighth grade) would show minimal receptivity to reward conditions encouraging goal interdependence in a mixed sex group. Therefore, Ss from the seventh and eighth grade will be compared under all three instruction conditions in heterosexual groups.

Level of achievement.

It is obvious that on any task Ss with a past history of high achievement are likely to have a greater success than those with a past history of lower achievement. It is far less obvious, however, to predict how high and low achievement students are affected by group discussion or by intra- and inter- group competition as compared with individual competition. There are two equally plausible and opposite predictions.

One line of reasoning is as follows. Academic achievement is culturally a highly individualistic, competitive enterprise. Breer and Locke (1965) show evidence that the rewarded experience of individualistic tasks tends to induce a generalized attitude of coping with a wide variety of circumstances with individualistic strategies. It would be expected then, that high achievement students, having a higher past history success rate for individually competitive behaviors would adapt more readily to the competitive than to the cooperative condition. Low achievement students having a past history of less success and even frequent failures under an individualistic strategy would be less conditioned to an individualistic strategy. Since the task in the present experiment is of moderate interdependence and demands collective behavior under equivalent instructions, it would be expected that high ability Ss would adapt more readily to the individualistic competition than the low ability Ss.

Another, opposing prediction might be made. High science achievement often correlates with a high verbal ability. Also, group discussion emphasizes the ability to express one's opinion with some clarity in order to communicate and thus influence another member's opinion. Therefore, it might be expected that high ability groups might be better able to utilize group discussion. Thus, high achievement Ss would score higher after group rather than individual conditions whereas, low achievement students would show less difference between group and individual conditions.

To compare achievement levels, Ss in both the seventh and eighth grade samples will be divided in half on the basis of scores on a basic skills composite score and a science achievement score. The top half of the Ss in each grade will constitute the high achievement sample. The final experimental design is presented in Table 1.

Adequate controls.

Many critics of small group research have argued that group superiority is due primarily to pseudo-effects--that is, to a series of theoretical and statistical artifacts--rather than due to any facilitation derived from the group interaction process itself. The simple statistical artifacts might be considered first.

Two statistical considerations, artifacts since they have no relation to group interaction, tend to inflate group productivity scores over individual scores. First, in problems requiring a minimum of one correct solution reached by one or more members of a group, the probability of one member of the group arriving at the correct solution by chance is obviously higher than the probability of any single individual reaching that solution. Then the group score is simply the score of the top individual on each item. (Shaw, 1932, as contrasted with Marquart, 1955). A second possible pseudo-effect concerns the criterion

Table 1

Experimental Design

Grade	Achievement	Class	Distribution of Rewards Equivalent	Differential	Individual
7	High	1	S_1	S_{27}	S_{54}
		2	.	.	.
		3	S_{26}	S_{53}	S_{79}
	Low	4	S_{80}	S_{104}	S_{129}
		5	.	.	.
		6	S_{103}	S_{128}	S_{151}
8	High	7	S_{152}	S_{175}	S_{199}
		8	.	.	.
		9	S_{174}	S_{198}	S_{215}
	Low	10	S_{216}	S_{235}	S_{255}
		11	.	.	.
		12	S_{234}	S_{254}	S_{276}

by which group products are considered superior. Although group products are often superior in speed and quantity to the "average" individual product, this superiority is rarely sufficient to compensate for the man-hours involved. Thus the solution of a four-man group is rarely 4 times faster, more accurate or more complete than that of a single individual. (Husband, 1940; Taylor and Faust, 1952)

In order to compare group effects due to interaction, uncontaminated with pseudo- or statistical group effects, it seems logical to compare individual scores of group members after interacting in groups with the scores of solitary individuals. Furthermore, the focus of this study is on individual learning as a result of group discussion, and individuals, not groups, learn. It is the social modification of individual solutions, not the combination or weighting of individuals' solutions to form a group product, that is of concern. Thus individual scores rather than group products will be the criterion measure.

A final consideration concerns the amount of information or knowledge that the members of a group possess. Some critics have felt that the group is superior to the individual because certain individuals possess superior knowledge and dominate the efforts or errors of the less knowledgeable members. Although this is a legitimate function of small group process, it might seem reasonable to limit its effects and thus focus on the communication and influence functions among members with relatively equal knowledge. Many studies have not adequately controlled or even specified the prior level of relevant knowledge possessed by the members.

Therefore, in order to reduce the range of knowledge available to a single group the following controls will be used in this study. First, in order to present a problem task new to all Ss, genetics problems will be used. Secondly, to equate member knowledge of relevant facts and principles, Ss will be taught by a standard programmed booklet. All Ss will complete the programmed booklet containing 33 response items with feedback at their own rate of speed. After presentation of the programmed facts and principles, Ss will be tested with feedback on all major facts and principles. They will also be retested on the day of the experimental session with a criterion of 90% correct for all Ss included in the experiment. Thus the relevant facts and principles will be equivalent for all team members as well as across conditions. In addition, Ss will be assessed for general science achievement level and each experimental team will consist of members in a relatively narrow range of ability. Specifically, Ss in each grade will be divided into six classes representing 6 rank ordered levels of achievement. All teams will consist of only members at the same ability level.

METHOD

Subjects

Two hundred and seventy-five seventh and eighth grade students in twelve regularly scheduled science classes participated in the experimental procedure. In addition, 16 other Ss participated, whose data were not reported. Three of these Ss failed to meet a criterion of 90% correct on the preliminary test of facts and principles. Thirteen Ss failed to complete the experimental task in the time allotted. All experimental Ss were drawn from one, small-town, consolidated junior high school and represented the school's total population after the elimination of special classes for the retarded and "slow learner" students. The town selected has a heterogeneous population with respect to economic and ethnic composition.

An additional 120 seventh and eighth grade students in six study-hall sections of a similar small-town junior high school were used to pre-test the efficacy of the instructional material and the difficulty level and discrimination index of the test materials. Individuals from a third town were used for the initial modifications in comprehension level of both the instructional and test materials.

Achievement levels.

Homogeneous groups of Ss consisted of students in the same class--classes having previously been assigned on the basis of the rank ordering of scores on the Iowa Basic Skills composite score, and the Stanford science achievement score (also, previous grades, teacher recommendation and I.Q.). One-third of the Ss in each class were randomly assigned to each of the three experimental conditions. Ss in the top three classes in each grade were considered High Achievement Level, those in the bottom three classes, Low Achievement Level.

Materials.

The experimental materials consisted of two parts--the instructional materials used to insure a standard set of knowledge for all individuals in all conditions, and the applicational problem solving materials.

The instructional material was in the form of a modified programmed booklet and accompanying review test. The program consisted of a series of short paragraphs presenting the basic components of genetics.[1] At the end of each paragraph and scattered between paragraphs of text were sentences containing one or more response blanks. There were a total of 33 response blanks within the program. The program and review test was in the form of an 11-page, 8½ x 11 mimeographed booklet. (See Appendix I). The booklet was constructed with a title page containing 5 basic words to accompany the verbal introduction, followed by three pages of text, an answer sheet, three more pages of text with an answer sheet, a review test sheet and the review answer sheet. The pages of text were of consecutive decreasing width with the answer sheet extending beyond the width of the text pages. On the answer sheets were response blanks (visible while reading the accompanying text) and the correct response (typed to the left of the response blank and not visible while reading the text page). Thus, response could be made on the answer sheet opposite the blank in the text and then immediately checked for accuracy by S turning over the edge of the page and observing the correct response typed on the answer sheet. (See Appendix I.) The mimeographed review test and accompanying answer sheet consisted of 15 fill-in type questions presented without printed answers.

The applicational problem solving test consisted of a 5-page 8½ x 11 mimeographed booklet and a single 8½ x 11 answer sheet. (See Appendix II). Each page contained background information in diagram and/or paragraph style presenting a genetic situation. This exposition was followed by a series of multiple-choice questions concerning this situation. The warm-up problem (page 1) contained three questions which were similar to the experimental problems. Each of the remaining problem situations contained six related questions.

The problem items were selected according to Bloom's categories of educational objectives (1956) to represent the process of "application" of facts and principles. Previously compiled and tested raw items (Dressel and Nelson, 1956) were selected, since the plausibility of the multiple choice alternatives had already been evaluated. Most items had to be re-written, however, to accommodate the lower reading comprehension of junior high school students. The answer sheet contained letters corresponding to the multiple-choice alternatives opposite the number for each question and sufficient space to indicate by circling and crossing, first and second choice responses, respectively.

In addition, a group cohesion scale, composed of a series of semantic differential scales, for subjective assessment of problem solving group cohesiveness, completes the applicational materials. (See Appendix III).

<u>Pretest.</u>

Since all materials were essentially original, it was necessary to test their efficacy in several phases.

First, the instructional program was administered individually to five students--two of above-average ability and three of low-average ability--to modify the clarity of presentation and reduce the error rate. Following this individual testing, the instructional material was administered under classroom conditions to one class of 23 above-average students and one class of 20 below-average ability students. This administration included a verbal introduction and post-test review in order to test for completion within one class period. This process resulted in 95% of the <u>Ss</u> completing the program in 25 minutes with 90% or better correct.

The next phase of pretesting involved both the modified program and the applicational problem test. Six problems, each with six multiple-choice items, for a total of 36 items were tested for difficulty level and discrimination index. Initially, pairs of students of similar ability participated. The program was administered in the standard individual form. Then, students working together as a pair, with <u>E</u> observing, discussed and attempted to solve the applicational test. Items were changed at this point for readability and comprehension but not for difficulty level. Then the completed materials were administered to four classes of <u>Ss</u> of both high and low ability levels. On the basis of this group data, items were analyzed for difficulty level and discrimination index. 24 items were selected which were of medium difficulty level and maximum discrimination index. Two of the four pre-test classes solved the applicational problems under small group discussion conditions.

Procedure.

The experiment consisted of two 45-minute sessions, conducted during regularly scheduled science periods on two consecutive days. An outline of the procedure is as follows:

Day 1 -- Instructional Phase

Introduction and Instructions--7 minutes

Program Booklet and Review Test--25 minutes

Oral Review--10 minutes

Correction and Collection of Papers--2 minutes

Day 2 -- Applicational Phase

Review Test--7 minutes

Division into Three Conditions--1 minute

Instructions and Warm-Up Problem--8 minutes

Problem I--6 minutes

Problem II--6 minutes

Problem III--6 minutes

Problem IV--6 minutes

Cohesion Measure--4 minutes.

Day 1 -- Instructional Phase

E was introduced to the class by the classroom teacher. Ss were told that they were taking part in an experiment to test some methods for implementing some new instructional materials. Their cooperation for the next two days was requested. E then distributed the programmed booklets, while briefly introducing the field of genetics. E attempted to keep the introductory comments as close to the standard form as possible. In the course of the introductory comments, E directed Ss attention to the five basic words printed on the cover of the booklet and necessary for later discussion. E repeated each of these words twice together with a partial clue to their meaning. E then instructed Ss in the use of the booklet. Ss were told:

> "Carefully read each paragraph in the booklet until you come to a blank. Then decide from the material you have just read, what word belongs in the blank. Fill in this word on your answer sheet opposite the number of that blank. When you have filled in the blank on your answer sheet, then lift the edge of the text page and look at the correct answer typed on your answer sheet next to the spot where you wrote your answer. If you were correct, you may continue to the next paragraph. If you were incorrect, you are to cross out your mistake and write in the correct answer, before you continue to the next item."

The first paragraph was then read aloud and demonstrated, complete with correction procedure. Ss were also shown the review test at the end of the booklet and instructed to complete this page without printed answers immediately after completing the program. After any questions had been answered, Ss proceeded through the program and review test without interruption for 25 minutes. At the end of 25 minutes Ss were told to stop, and E conducted an oral review based on the review test. Ss answered as a class the review items, discussing the relevant reasoning and related questions. Ss were instructed to correct their test papers by crossing out incorrect items and filling in the correct response. All papers and booklets were then collected and the class dismissed.

Day 2 -- Applicational Problem Solving.

At the beginning of the session, Ss were again given the answer blank for the review facts and principles test. Questions were read orally in two halves, with the answers given after each half of the test. Answers were given in context, as

"The gene pattern of the individual is called the genotype."

rather than

"The answer to number 6 is 'genotype'."

Ss were not instructed to correct their own answers but only to note what the correct answer was. (Knowledge of results.) At the completion of the facts and principles test, Ss were randomly assigned to the three experimental conditions and directed to three separate rooms. Three E's were used for this phase of the experiment--the original E and two others. (Since each cell in the experimental design contains Ss from three classes, the E's were completely counterbalanced.)

All Ss were given an applicational problem solving booklet and one answer sheet. In the group discussion conditions Ss were also randomly divided into discussion groups of three members each.

Instructions.

All Ss were told that they were competing and that three of the nine Ss present would receive an A in this project and have their scores posted the following week in science class. All Ss were discouraged from guessing and encouraged to use all available information. All Ss were told that they were to indicate their first and second choice. The three experimental conditions were then established by differential instructions.

1. Equal Reward Group--Team Cooperation (E)

> "To encourage you to do your best, we will have a little team competition between these groups. We will add the scores of each member of your group together. Then we will pick the winning group out of these three groups. The names of all the members of the winning group will be posted (next week) in your science class."

Ss were then shown the booklet, told to read and discuss the first problem situation and all the related questions, then turn away from their group and mark their own answers independently. Again before starting the practice problem, Ss were reminded of the competition:

> "Remember the scores of your group will be combined to determine the winner, so the group with the best discussion and suggestions will get the highest score."

After the practice problem, Ss were instructed to mark their first choice with a circle and their second choice with an X. Before each problem, Ss were reminded of the competition or the value of discussion. For example,

> "Remember to win you will want every member of your group to understand as much as possible about this problem."

or

> "Use your discussion to consider all the possible facts and principles that might apply to this problem."

Ss were given four minutes of uninterrupted discussion for each problem situation and then gently warned to finish their discussion and mark their answers in the next two minutes. After a total of six minutes on a problem, Ss were told they should be about ready to go on to the next problem. At this time reminders of reward conditions were given.

2. Differential Reward Group--Intra-Team Competition (D)

> "To encourage you to do your best work, we will have a little competition... You've been divided into discussion groups. But in each group of three, the pupil with the highest score will win. The names of the winners will be posted in your science class next week. This is Group X; Group Y; and Group Z. For each group there will be a winner."

Ss in this condition were given the same instructions to read and discuss the problem situation and all the questions with their group and mark their own answers independently. Then they were again reminded of the competition.

> "Remember, in each group the pupil with the top score will win, so use the group discussion and suggestions to learn as much as possible about the problem."

Ss in condition (D) were given the same four minutes of uninterrupted discussion for each problem, followed by a warning to complete their discussion and mark their answers independently in the last two minutes. They were also warned when it was time to begin the next problem and reminded of the experimental conditions. Reminders were as follows:

> "Remember, the pupil with the highest score in each group will win."

or

> "Use your discussion to consider all of the possible facts and principles that might apply to this problem."

3. Individual Reward Group--No Discussion (I).

> "To encourage you to do your best work, we will have a little competition... We will add the total score for each student. Then the three students with the highest scores will win. The names of the winning students will be posted next week in your science class."

Ss in the individual condition were shown the booklet, told to read and "carefully consider" each problem and all the related questions. Then, when they have thought through the problem, they were to proceed to mark their answers. Ss were then reminded of the competition and the necessity of considering their answers carefully before marking them down. After instructions following the practice problem, individual subjects proceeded at their own rate of speed. Every six minutes Ss were interrupted, to be told which problems they would be working on and reminded of the competitive factors.

In the (E) and (D) conditions, during the last four minutes Ss disbanded their groups, and the cohesion sheet "My Group" was distributed. The scale was demonstrated on the board, and Ss were instructed to describe on the scale the group with which they had just worked.

Dependent Measures.

The analysis of the applicational problem solving task included three separate measures--accuracy, consensus and cohesion.

Accuracy was measured as the total number of correct first choice answers out of a possible 24 problems for each individual S.

Consensus was defined as the degree of agreement within a group with respect to the total number correct. The following procedure was used to determine consensus scores. In the two group conditions, the absolute deviation of each score from the discussion group mean was the raw score for consensus. As a control for chance deviation a similar statistic was generated for the individualistic condition. All Ss were randomly assigned, using a table of random numbers, to three member groups with the added constraint that all group members come from the same class. Then, the absolute deviation of each score from this group mean was similarly computed. These deviation scores from all three conditions were then used as the basic data for an analysis of variance. Levine (1960) and Glass (1966), using deviations from cell means rather than deviations from small group means, suggest this procedure as a robust test for homogeneity of variance.

The cohesion measure was derived from the 13 semantic differential items of the group atmosphere scale entitled "My Group." Each item was recorded on an 8-point scale from negative to positive evaluation. Twelve of these items had previously been used in the literature as either a single scale of group cohesion, or as two components of group atmosphere with six items representing a socio-emotional scale and six items representing a task efficiency scale. (Julian and Perry, 1964). Therefore 13 items were factor analysed to determine whether this scale was in fact a unitary scale, a two factor scale as suggested by Bales (cited in Kelley and Thibaut, 1954), and Julian and Perry (1964), or a multi-dimensional scale. Since the distribution of scores on all items was skewed, scores were transformed to dichotomous values above and below the median and a tetrachoric correlation used. A principle factors analysis using the largest r's in the diagonals resulted in a single factor with a sum of squares larger than 1.0 which accounted for 74.49 percent of the communality. (See Appendix VIII for the unrotated factor matrix.) All semantic differential items had loadings on Factor 1 of .63 or higher except for Item 4 "Lots-of-fun versus serious." Therefore Item 4 was omitted from the scale and the remaining items were combined to constitute a unitary scale. The resultant raw score cohesion measure for each S was, therefore, a simple total of the dichotomous values on each item.

RESULTS

The analysis of the applicational problem solving task included the three separate dependent measures of accuracy, consensus and cohesion. All three measures were analysed in a simple 2 X 2 X 3 analysis of variance. A least squares computational method was used since the cells varied in the number of observations.[2]

<u>Accuracy</u>.

Table 2 presents the results of the analysis of variance of the number of correct responses to the problems. Table 3 presents the corresponding cell means and standard deviations. As expected, high achievement level students averaged clearly above low achievement level students. ($F=60.21$, $p<.001$.) As demonstrated in figure 1 and reflected by the lack of significant interactions involving achievement level, high achievement level <u>Ss</u> perform consistently above the low achievement <u>Ss</u> under all experimental conditions. (Although there is no assumption of an ordinal scale for distribution of rewards, the three conditions will be presented in a consistent order in all figures for simplicity.)

A second finding indicates that eighth grade <u>Ss</u> scored significantly higher than seventh grade <u>Ss</u>, ($F=4.04$, $p<.05$.) However, the significant Grade X Instructions interaction ($F-4.16$, $p<.025$.) indicates that the eighth grade is not consistently superior to the seventh grade performance over all experimental conditions, as demonstrated in figure 1. An analysis of simple effects indicates that the eight grade was signifi-

Table 2

Analysis of Variance of the Number of Correct Responses

Source of Variance	d.f.	M.S.	F	p
Grade	1	38.32	4.04	$p < .05$
Achievement Level	1	570.67	60.21	$p < .001$
Instructions	2	54.96	5.80	$p < .005$
Grade X Achievement	1	1.84	0.19	
Grade X Instructions	2	1.25	4.16	$p < .025$
Achieve X Instructions	2	1.25	0.13	
Grade X Achieve X Inst.	2	10.88	1.15	
Error	262	9.48		

Table 3

Means and Standard Deviations of Total Number of Correct Response in the Applicational Problem Solving Test

	Seventh Grade		Eighth Grade	
	Mean	St.Dev.	Mean	St.Dev.
High Achievement				
Coop.	12.308	3.247	14.870	4.808
Comp.	12.407	3.249	13.833	3.345
Ind.	12.520	3.002	11.294	2.867
Low Achievement				
Coop.	9.583	1.998	11.222	2.340
Comp.	10.320	2.577	10.400	3.050
Ind.	9.087	2.811	9.136	2.550

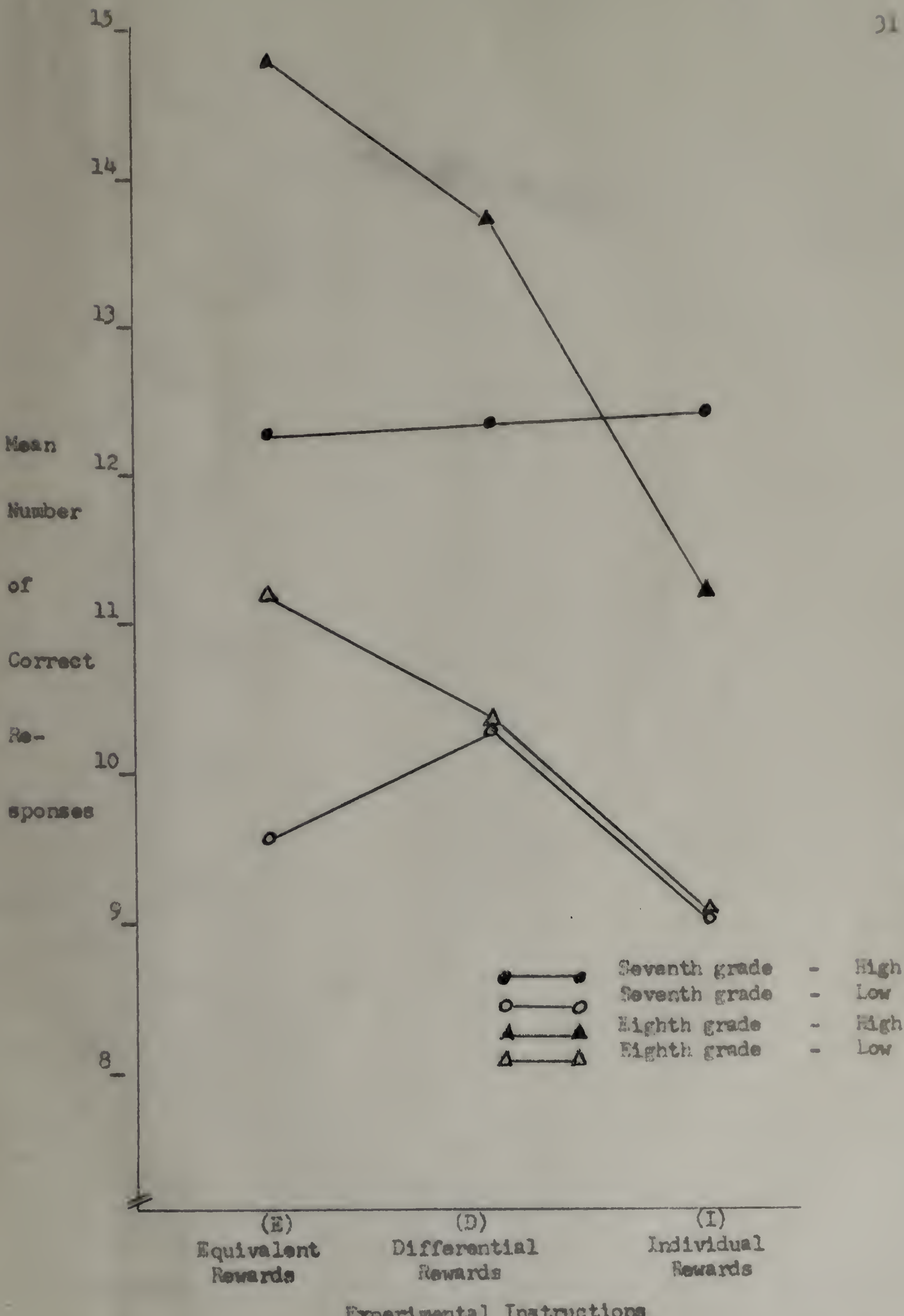

Figure 1. Mean Number of Correct Responses as a Function of Experimental Instructions for each Achievement Level in each Grade.

cantly superior to the seventh grade only in the equivalent reward (E) condition. (F 8.95, Scheffe's EW $p<.05$) and was not significantly different in the differential (D) reward condition or in the individualistic (L) condition.

Table 2 also indicates that there was a significant effect for the experimental instructions. ($F = 5.80$, $p<.005$.) An analysis of paired contrasts indicates that both the equivalent and the differential reward conditions were significantly higher than the Individualistic condition (F's of 10.1 and 7.8 respectively) using a conservative Scheffe' test for experimentwise error rate. ($p<.05$) The two group discussion conditions did not differ significantly from each other. Furthermore, considering the interaction between grade and instructions, it is clear that much of the difference between conditions is reflected in the eighth grade and not in the seventh grade scores. An analysis of each grade separately indicates a significant Instructions effect for grade eight ($F=7.39$, $p<.001$), and no significant Instructions effect for grade seven.

Consensus.

Table 4 presents the results of the analysis of variance of deviation scores with the corresponding cell means and standard deviations listed in Table 5. Experimental instructions was the only significant source of variance with an F of 9.96 and $p<.001$. As can be seen in Figure 2, the equivalent reward condition produced greater consensus (less deviation) than the other two conditions. In addition, the individual condition led to greater chance deviation than the other two discussion group conditions. It might be pointed out that in the

Table 4

Analysis of Variance of Deviation Scores

	d.f.	Mean Square	F	p
Total	241			
Grade	1	2.78	1.96	
Achievement	1	0.64	0.65	
Instructions	2	14.09	9.96	$p<.001$
Grade X Achieve	1	0.55	0.39	
Grade X Instruct	2	0.01	0.01	
Achieve X Instruct	2	2.10	1.49	
Grade X Achieve X Inst.	2	3.73	2.64	$p<.10$
Error	229	1.41		

Table 5

Means and Standard Deviations of Deviation Scores

	Seventh Grade		Eighth Grade	
	Mean	S.D.	Mean	S.D.
High Achievement				
Equivalent (E)	1.11	1.25	0.94	1.13
Differential (D)	1.11	1.24	1.36	0.97
Individual (I)	2.25	1.81	1.73	1.68
Low Achievement				
Equivalent (E)	0.83	0.74	0.94	1.23
Differential (D)	1.69	1.16	1.44	1.26
Individual (I)	1.55	0.94	1.66	0.91

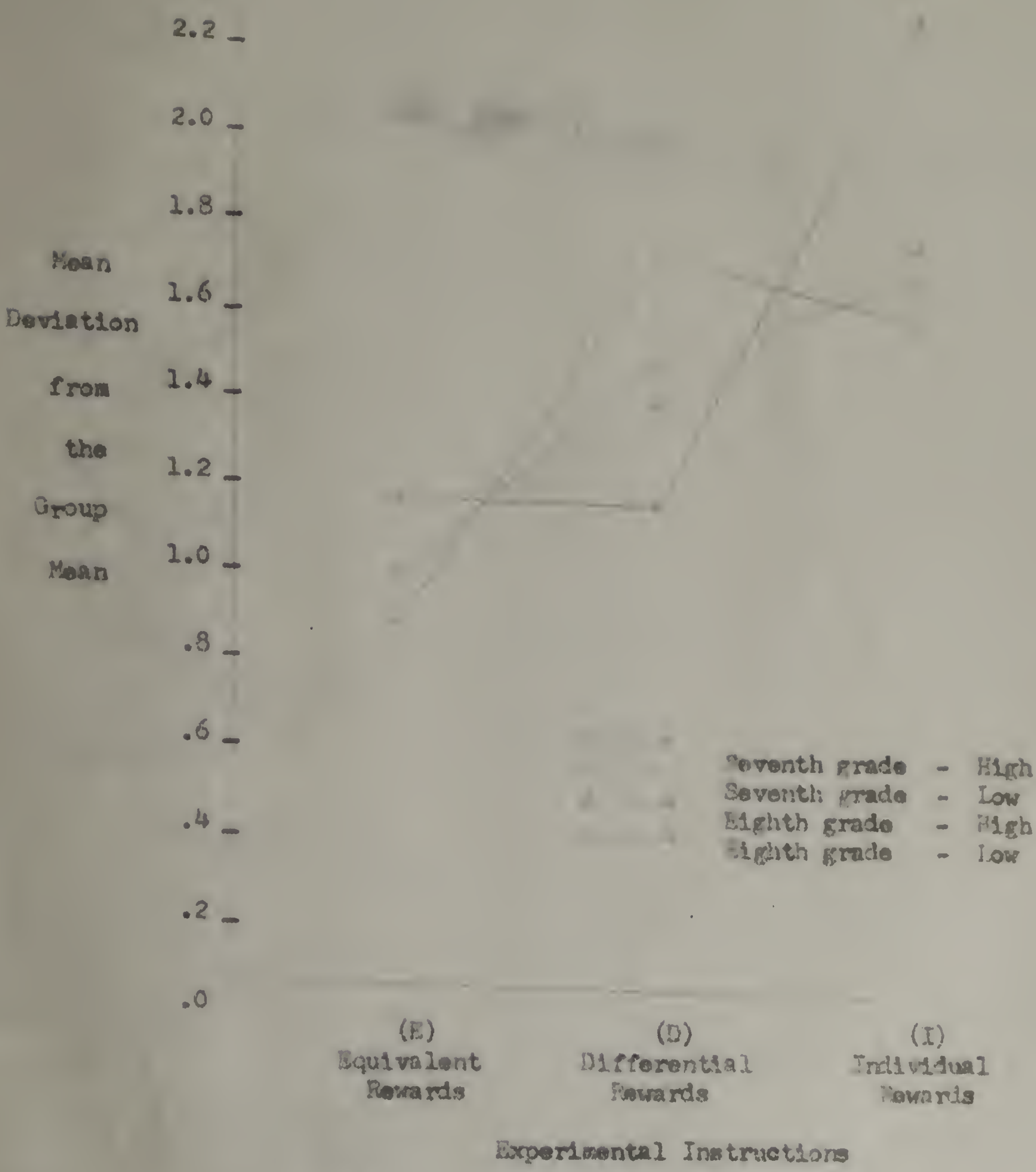

Figure 2. Mean Deviation Score as a Function of Experimental Instructions for each Achievement Level in each Grade

(I) condition, consensus represents deviation form a statistical group rather than an interacting group.

Cohesion.

Table 6 and 7 present the analysis of variance and corresponding means and standard deviations for the cohesion index. Cohesion scores were available only on the interacting group conditions. The single significant result indicates that low achievement level Ss rated the groups higher in group cohesion than did the high achievement level Ss. ($F=4.02$, $p<.05$) Figure 3 illustrates this relationship especially with respect to grade eight. Figure 3 also suggests a tendency for the eighth grade scores and the seventh grade low achievement scores to be higher in the equivalent (E) condition than in the differential (D) condition with the reverse true in the seventh grade high achievement conditi ons. However this triple interaction was not significant. ($F=2.68$; $.10\ p<.20$)

Table 6

Analysis of Variance of Cohesion Scores

Source of Variance	d.f.	Mean Square	F	p
Total	166			
Grade	1	7.33	0.43	
Achievement	1	68.45	4.02	$p < .05$
Instructions	1	29.94	1.76	
Grade X Achievement	1	45.65	2.68	$p < .20$
Grade X Instructions	1	8.28	0.49	
Achieve X Instruct.	1	16.47	0.97	
Grade X Achieve X Inst.	1	45.65	2.68	$p < .20$
Error	158	17.02		

Table 7

Means and Standard Deviations of Cohesion Scores

Reward Conditions	Seventh Grade		Eighth Grade	
	Mean	S.D.	Mean	S.D.
High Achievement				
Equivalent (E)	5.88	3.50	4.79	4.29
Differential (D)	7.22	3.52	4.13	3.73
Low Achievement				
Equivalent (E)	7.88	3.22	7.91	3.18
Differential (D)	5.71	3.41	7.00	3.89

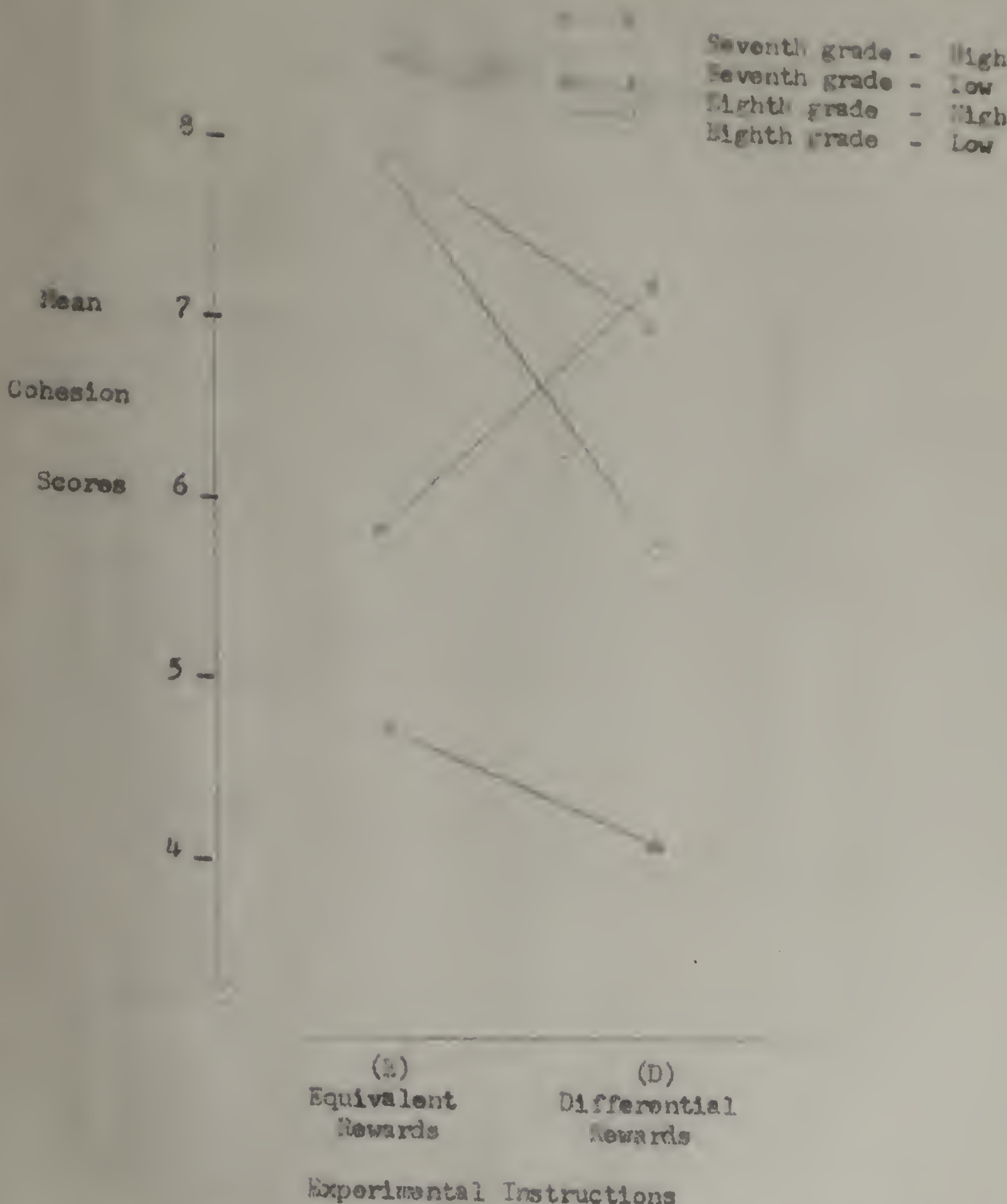

Figure 3. Mean Composite Cohesion Score as a Function of Experimental Instructions for each Achievement Level in each Grade

DISCUSSION

Group versus Individual Performance.

In general Ss in a small group discussion conditions performed better than Ss in the individualistic condition. An analysis of the simple effects indicates that the equivalent and differential reward conditions differ from the individualistic condition with F's of 10.1 and 7.8 respectively. Using Scheffe's technique for accounting for experimentwise error rate these F's are both significant with a $p < .05$. (Scheffe's procedure was used since it provides a more conservative test of simple effects than other multiple comparison techniques and is less sensitive to possible violations of normality or of homogeneity of variance assumptions). This group superiority is in accord with the results of several other studies (Shaw, 1932; Husband, 1940; Taylor and Faust, 1952; Lorge et al, 1965).

In this experiment, however, there was an attempt to limit the effect of group discussion to communication and influence factors rather than large heterogeneity among group members. All Ss reported being unfamiliar with genetic principles prior to the study. All Ss received equal programmed instruction in the requisite facts and principles. Finally all Ss achieved a score of 90% or better on a test of these facts and principles just prior to problem solving. Thus the level of knowledge among group members as well as conditions could be assumed to be relatively equivalent. Furthermore, discussion groups were formed of Ss who were on one of six levels of general ability and achievement as determined by the Stanford Science Achievement Test and the Iowa Basic Skills-composite score. Thus group members were relatively homogeneous with respect to reading ability, comprehension, reasoning and other cognitive skills. A reduction in group member heterogeneity of skills and knowledge thus provides a more stringent test of group superiority.

In addition, Ss in both the small group conditions and the individualistic condition were given an equal amount of time on the problems. However, despite an equal allotment of time, most groups reported being somewhat rushed while most individuals completed each section of 6 problems early and waited unoccupied for instructions to begin the next section. This early completion probably represented premature incorrect conclusions since only 3 individuals responded correctly on 18 or more items out of 24 possible items. The top individual score was 21. In comparison, 16 Ss in the group conditions achieved a score of 18 or better including 2 perfect scores. It is suggested that group discussion may provide the stimulus for a more extended consideration of possible alternative explanations and thus to error correction.

Age-Grade Differences.

The superiority of small group discussion over individual problem solving is true only for the eighth grade as indicated by the significant grade by instructions, interaction and demonstrated in Figure 4.

Much of the difference between experimental instructions is accounted for by the eighth grade. In fact, an analysis of the seventh grade alone yields no significant difference due to instructions.

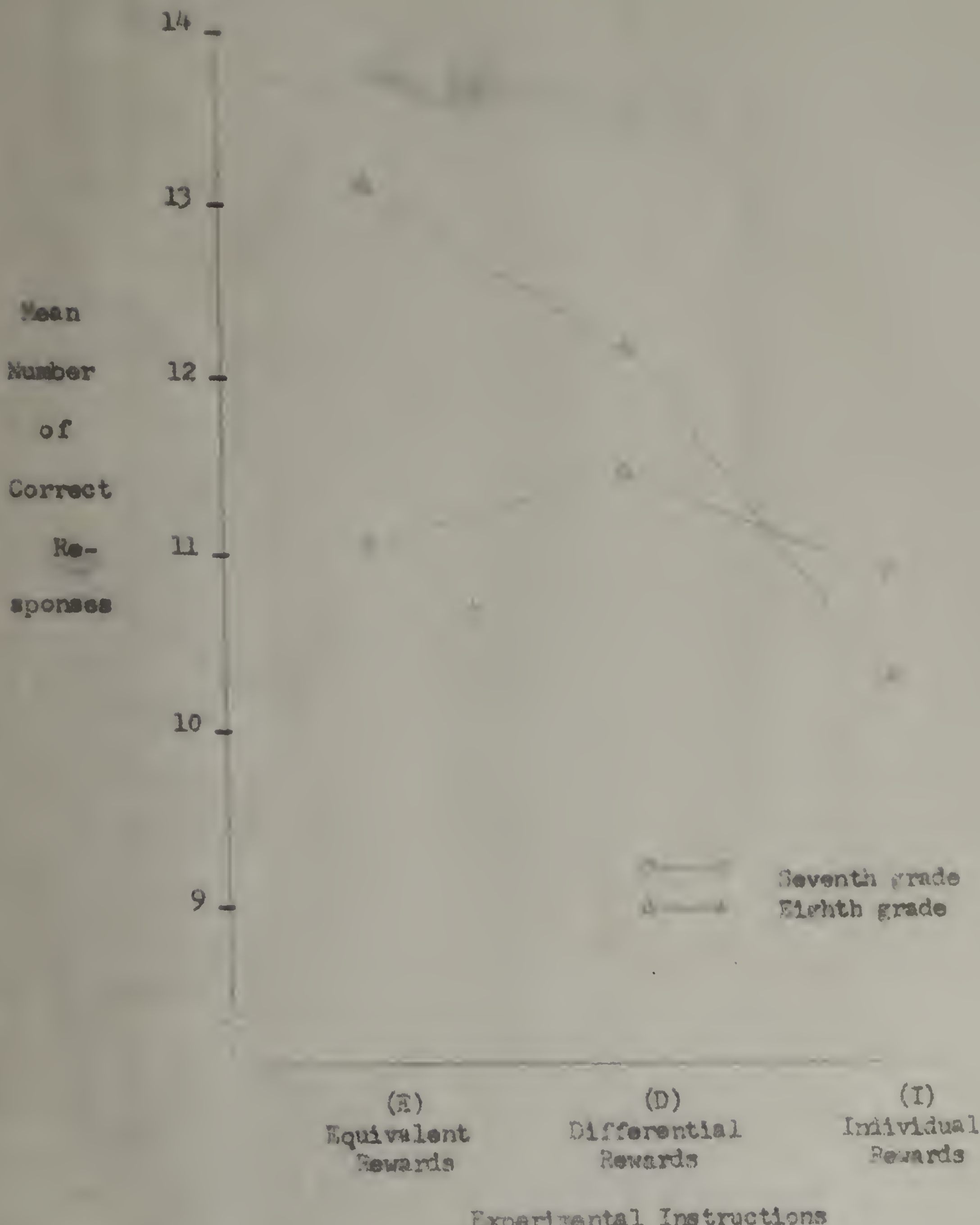

Figure 4. Mean Number of Correct Responses as Function of Experimental Instructions for each Grade Level

Furthermore the superiority of the eighth grade over the seventh grade is due to the difference between the two grades in the equivalent reward condition. The eighth grade equivalent reward condition is significantly higher than the seventh grade equivalent reward condition ($F=8.95$, Scheffe's $p<.05$). A separate analysis of the cooperative condition and a separate analysis of the individualistic condition yielded no difference between the grades under these instructions. Thus the only difference between the grades exist in their reaction to the equivalent or cooperative instructions.

As previously hypothesized, the general differences between seventh and eighth grade Ss can be classified into two types- cognitive and socio-emotional. The differences between these two ages with respect to comprehension, reasoning and other general cognitive abilities necessary for problem solving should be minimal. This is supported by the similarity of scores for Ss in the individualistic conditions. However, within this narrow age span of seventh and eighth grade Ss there are marked changes in socio-emotional style due to differential growth rates between the sexes in social and physical maturation. The end of the seventh grade year marks a period of maximum difference between the sexes--the majority of girls having reached pubescence, and the majority of boys not. Harris and Tseng (1957) have found a sharp increase in girls' unfavorable attitude toward boys beginning in the fifth grade and reaching a peak between sixth and seventh grade. This corroborates an earlier finding that there is a peak in antagonism between the sexes at about the sixth and seventh grade primarily because of girls resentment. (Koch, 1944). Considering this divergence, it is quite likely that at this age it is particularly difficult to form a task-oriented heterosexual group with effective problem solving communication.

A further analysis of homosexual and heterosexual equivalent reward groups at both grade levels would be helpful but there are too few groups per condition to analyze. A casual observation of performance and group composition is suggestive however. Of the five heterosexual groups in the seventh grade, high achievement, equivalent reward condition, four groups showed a mean performance lower than the grand mean for all Ss of low and high achievement levels. In addition, these groups showed lower cohesion scores and larger deviation scores than average. In contrast, in the eighth grade high achievement, equivalent reward condition, the only discussion group scoring below the grand mean on problem solving was an all male group recorded as high in cohesion. It is certainly suggestive of the fact that group sexual composition may be an important variable in interaction with age-grade level.

Distribution of Rewards in Group Discussion Conditions.

Although in general, groups scored higher in problem solving than did individuals there was no significant difference between performance under the equivalent and the differential reward conditions. This was true not only comparing all Ss but also a separate analysis on each grade yielded no significant differences between the two group discussion conditions in either the seventh or the eighth grade. ($F=0.55$ and 1.42 respectively.) This is in contrast to findings in several other studies where the task was assumed to be relatively interdependent. (Miller and Hamblin, 1963). There are several possible reasons for this discrepancy.

Consensus.

It is first necessary to establish whether or not the distribution of reward instructions had any effect on the two group discussion conditions. It is possible that the incentive may have been too mild to have any marked effect on behavior. However, a comparison of the consensus scores of the equivalent (E) and differential (D) reward conditions indicated that Ss in the (E) condition showed significantly greater consensus (less deviation from the group mean) than did the Ss in the (D) condition. ($F=7.17$, $p<.05$ Scheffe) Thus the incentive conditions were sufficient to produce some degree of conformity versus divergence giving some validity to the experimental instructions.

Task difficulty.

A second consideration with respect to incentive conditions is the difficulty level of the task. All test items were previously selected to be of moderate difficulty (20-80% difficulty index corrected for chance) on the basis of a pretest population of 92 Ss. However, it was noted that in the experimental population of 275 Ss only 2 Ss received a perfect score of 24 correct responses, and only 19 Ss received a total score of 18 or more correct responses. These figures suggested that the test was somewhat more difficult for the experimental population than for the pretest population. A post hoc analysis of the difficulty level of each item for the experimental population yielded only 16 of the 24 items which were of medium difficulty. (See Appendix IV.) It would seem that the two populations were not equivalent with the test being of moderately high difficulty level for the experimental Ss. The higher difficulty level of the test produced a ceiling effect reducing the variability of most scores to a range of 6 (chance level) to 16. The net effect of a test with a high rather than moderate difficulty level should be to reduce the effect of any independent variables. In addition, a difficult task may be frustrating, thus occasionally the role of social support in group interaction may become more important than problem solving.

Cooperation-Competition Definitions.

A third consideration with respect to a comparison of the two group conditions concerns the definition of the experimental variable--distribution of rewards. In contrast to other research, this variable of distribution of rewards was more circumscribed than the other definitions of cooperative and competitive conditions. Deutsch (1949) has larger experimental differences between his cooperative and competitive conditions in that he has a somewhat different task in each condition as well as distribution of rewards. In this study the tasks for both equivalent and differential reward conditions are identical and involve individual rather than group products for both conditions. Furthermore, in contrast to Phillips and D'Amico (1956) and others, the amount of incentive and the ratio of winners to members is constant for both the equivalent and differential reward conditions. Perhaps distribution of rewards (or interdependent incentive) is a less potent variable than the variable of interdependent means.

As Thibaut and Kelley (1959) and game theory suggest in their definitions of cooperation and competition, it is necessary to account for all the outcomes in a situation. A cooperative condition must have high correspondence of the outcomes of individual members; a competitive condition must have negative correspondence of all outcomes. In this study despite an attempt to simplify the distribution of rewards variables, there are most likely at least two goals in this task. First, to complete the task with some degree of competence or understanding and secondarily to win the reward. Only the second of these goals was manipulated experimentally, with the (E) condition having perfect correspondence and the (D) condition having negative correspondence. In an ordinary laboratory experiment using puzzles or games as tasks the first goal may be incidental. However, the fact that this experiment was conducted in a science class period as part of the science curriculum for the year and with the full support and authority of the regular science instructor, amy have enhanced the first goal. A "learning for learning sake" or a problem solving for the sake of completion is a goal of undetermined strength. Certainly the Zeigarnik effect, indicating that unfinished tasks are remembered more easily suggests a goal of completion which is of measurable importance. Such problem solving motivation is probably stronger in the classroom than in the laboratory, (Miller and Hamblin, 1963) and stronger in the acquisition and performance of course related problems than in the performance of more general or novel puzzles and games (Lorge et al, 1958). In this experiment it was commented that the incentive conditions interfered with their desire to solve the problems with their friends or various related complaints indicating their dissatisfaction with the "gamesmanship" required by the differential incentive instructions. Collectively they strongly express mixed motives with respect to group communication.

Age-grade.

The fourth and most important consideration with respect to the similarity of performance in the equivalent and differential reward conditions is the previously mentioned difference between the seventh and eighth grades. The eighth grade equivalent condition was significantly higher than the seventh grade equivalent condition ($F=8.95$, Scheffe $p<.05$). Therefore whatever superiority was reflected in the eighth grade (E) condition was not supported in the seventh grade (E) condition.

Thus the similarity of equivalent and differential reward conditions in contrast to other studies, may be due to a moderately high task difficulty level, a more circumscribed definition of cooperative versus competitive incentives, an additional and equal motive of science competency, or the low degree of cooperative interaction among seventh grade heterosexual discussion groups.

Cohesion.

A final consideration must be given to the group cohesion scale. Semantic differential items such as this have frequently been used on the basis of face validity to measure group cohesion. (Julian and Perry, 1964). Little evidence is available as to whether such ratings can be considered as unitary single factor measures or as complex measures. In this experiment, using junior high students after only thirty minutes of group interaction, the results of factor analysis indicate support for a single factor interpretation. One factor accounted for 75.49 percent of the communality (Appendix VIII). However, since the Bales hypothesis of a task oriented, and socio-emotional component of group cohesion is frequently cited, a rotation of the four largest factors was attempted. An oblimin rotation yielded two factors partially meeting Bales definition (Appendix IX). "Successful" "productive" "cooperative" and to a lesser extent "helpful" "kind" and "accepting" have high leadings on Factor I. "Friendly", "close", and "warm" have high loadings on Factor II. However, since the correlation between these two reference factors is .42, their existence as separate factors for this population was highly questionable. Perhaps in brief interaction with ad hoc groups there is insufficient time to build up more than a gross evaluation of group functioning. Thus one factor is sufficient to describe the type of evaluation made in this experiment.

If one factor is indicated, the next question involves whether this factor is best termed group cohesion. The analysis of variance of the composite cohesion score indicates only one significant independent variable. Low achievement level Ss rated their groups as significantly more "Cohesive" than high achievement level Ss. ($F=4.02$, $p<.05$). There are at least two possible explanations for this relationship. This higher rating may be a simple response bias whereby slower students may be more positive about their interpersonal traits in general. A second possible reason could be specific to this experiment. Low achievement level Ss may have experienced more frustration and thus compensated for feelings of hopelessness or inadequacy by rating the group experience higher. Lott and Lott in their review of cohesion studies (1965) conclude that Ss generally increase their cohesion in response to frustration or threat. However, they further conclude that Ss increase their cohesion after failure only if they perceived cause of failure is some external arbitrary source not their own ineptitude. Whether this conclusion applies in this experiment is a matter of interpretation. If this is the case, however, one might term this scale a cohesion scale.

Implications for future research.

The evidence in this experiment seems quite clear that seventh grade students react differently to instructions to work cooperatively and share a reward than do eighth grade students. Furthermore, this is not entirely an isolated finding as Harris and Tseng (1957) and Koch (1944) using quite different tasks find greater animosity between the sexes at precisely the sixth and seventh grade level, with a marked improvement at the eighth grade level. The degree and generality of this age difference needs further exploration. However, it seems clear that developmental differences must be accounted for in small group studies, especially when heterosexual groups are involved.

A second implication concerns the complex nature of cooperation-competition. In this experiment the definition of cooperative and competitive conditions was limited to the type of distribution of rewards and tested using applicational problem solving as the interdependent task for both group conditions. However the manipulation of the distribution of rewards did not prove to be a potent enough variable to produce cooperative superiority as predicted. (Miller and Hamblin, 1963). It is possible that the incentive was not large enough to provide sufficient motivation. Perhaps this was not the most important aspect of the cooperative-competitive complex. It is also possible that there were other goals, present in the situation but not manipulated, that provided stronger motivation for the presence or absence of cooperative discussion behavior. All of this simply underscores the complex nature of cooperation and competition and the need for further delineation of the subordinate variables. Laboratory studies which manipulate both task dimensions (interdependence, difficulty), and goal dimensions (external and internal incentives, amount of incentive), independently would clarify this issue.

A further uncertain variable is the issue of group heterogeneity. In this experiment, there was a deliberate attempt to limit the variability of knowledge and skills available to group members. Despite these stringent controls, groups performed better than did individuals. However, under these controls, cooperative conditions did not exceed competition. If group process is primarily the result of pooling diverse individual abilities, the superiority of cooperative groups may be markedly curtailed when group variability is limited; or conversely competitive groups with limited variability between Ss ability may have little success with competitive behavior. Although the interaction of group heterogeneity in group versus individual studies has been explored (Timmons, 1942) and others cited in Lorge et al, 1953), the relationship between group heterogeneity and cooperative-competitive conditions is yet to be investigated.

Considering the foregoing implications a final comment on the contribution of classroom research seems in order. Although the present study lacks finality of conclusions, it does generate several hypotheses for testing in laboratory and classroom. Lorge (1953) and Davis (1966) have bemoaned the lack of "reality" in small group problem solving research, limited to games and puzzles in the laboratory. Hilgard (1964) has suggested a continuum of research generating theories of instruction ranging from basic laboratory research often using small animals to classroom research using course content materials. He emphasizes the fact that all points on the continuum feed each other hypotheses generalizability and clarification. Certainly this experiment can be considered an exploration in "reality testing" of laboratory findings.

SUMMARY

From the complex area of cooperation-competition research the single variable of distribution of rewards was singled out for manipulation.

Seventh and eighth grade Ss at two achievement levels were compared on applicational problem solving under three types of competitive conditions. Condition (E) Ss worked in three-member cooperative teams with each team competing for an A project grade against two other teams. All members of this team would receive equivalent (E) grades. In condition (D) Ss also worked in three-member groups but with each S competing with the other two members of his own group. In condition (I) Ss worked independently with a ratio of one in three Ss receiving the grade A reward. Ss in all conditions reported their answers individually whether or not they had discussed the problem in a group. An attempt was made to reduce group heterogeneity by constructing discussion groups of Ss at the same general ability level and by teaching all Ss the specific facts and skills required in the problems by programmed instruction and testing of the obtained factual knowledge. The experiment was conducted in the classroom as part of a regularly scheduled science assignment.

The results indicated that Ss who worked in groups generally excelled those who worked independently. This result, however, was primarily a result of eighth grade group superiority; a result not

significantly supported in seventh grade performance. Developmental differences between the two grades with respect to social interaction in heterosexual groups were hypothesized to account for the divergence.

A further result indicated that Equivalent (E) and Differential (D) reward conditions did not differ from each other with respect to problem solving accuracy although the Equivalent condition demonstrated greater group consensus. Several explanations were suggested. Among these explanations was the possibility of a mild incentive, the reduced heterogeneity of discussion groups, the task difficulty, the developmental animosities in heterosexual groups; or the simple fact that distribution of rewards may not be the most important variable in previously cited comparisons of cooperation and competition.

High achievement level <u>Ss</u> performed higher than low ability <u>Ss</u>, but both achievement levels responded similarly to experimental conditions.

A subsidiary analysis of the cohesion scale yielded a unitary or single factor scale rather than a multi-dimensional scale.

Footnotes

[1]Verified from Biological Curriculum Study Committee, Biology (yellow version).

[2]Computed on a Control Data 3600, using UMECFREQ, a University of Massachusetts library program.

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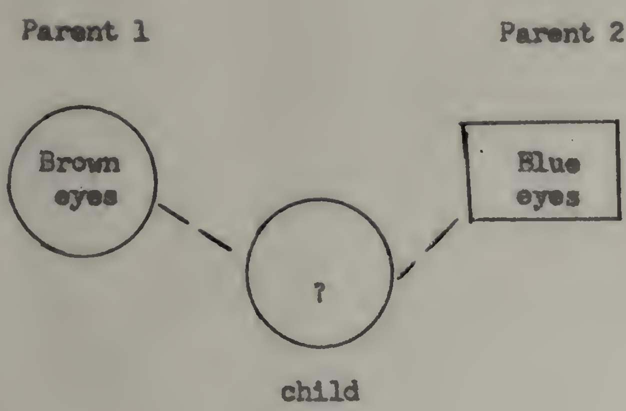
APPENDIX I

Programmed Instruction

HEREDITY

1. Genes
2. Dominant
3. Recessive
4. Phenotype
5. Genotype



I. This is a program about heredity, that is, about the traits that you inherit from your parents. You will learn how living things pass on traits to their offspring.

Those traits that you inherit from your parents at birth are sometimes called your ____(1)____.

Not only people, but all plants and animals produce offspring something like themselves. Generation after generation, living things reproduce themselves. Long horn cattle reproduce long horn cattle. Orange poppies reproduce orange poppies. What makes the poppy seeds produce orange poppies rather than white poppies or violets or roses?

Each poppy seed contains microscopic chemical instructions that control and limit the plant's growth into an adult plant. These chemical instructions in all plants and animals are called genes.

We call these chemical instructions the ____(2)____.

These genes are passed from parent to offspring in the seeds of the plant or animal. This is what makes the orange poppy seeds produce orange poppies rather than violets or roses. It is the genes that determine heredity.

The chemical instructions in living things which determine heredity are called ____(3)____.

Plants and animals have many characteristics that are determined by genes. Such characteristics, or traits, are things like eye color, straight or curly hair, long or short fingers, a flower's color, the length of a dog's tail and so forth. For any particular trait, there are TWO genes in every individual.

For example, if we are talking about a child's eye color, we know that he has a pair of genes, or ____(4)____ (How many?) genes for eye color.

We often use letters to stand for the genes. If a capital B stands for brown, a boy with brown might have two genes for brown eyes. We would say his genes were BB.

These letters (BB) stand for two genes for ____(5)____ (What color?) eyes.

Genes are best thought of as microscopic chemical ____(6)____ that determine heredity.

II. For any particular trait, such as eye color, the two genes may or may not be exactly alike. It is important to know whether the two genes in a pair are alike or different.

Look at this pair of genes.

BB

Both genes are for brown eyes, not blue eyes or green eyes. We will call this a like pair.

Now look at this pair.

bb

A small b stands for blue. Since there are two b's just alike, this pair too is a ___(7)___ pair.

Sometimes the two genes are not alike. Look at this pair.

Bb

This individual has one gene for brown eyes (B) and one gene for blue eyes (b). If the two genes in a pair are different, we call this an unlike pair.

The gene pair Bb is an ___(8)___ pair of genes.
(like/unlike?)

Are these gene pairs like or unlike?

BB is a ___(9)___ pair.
Bb is a ___(10)___ pair.
Sc is a ___(11)___ pair.
cc is a ___(12)___ pair.

III. What determines whether the individual will have brown or blue eyes? (Remember genes are the instructions for blue or brown eyes, not the eyes themselves.) If both genes are for brown eyes, or both genes are for blue eyes then the answer to the question is easy. Two like genes for brown eyes produce brown eyes. Two like genes for blue eyes produce blue eyes.

Two genes for straight hair produce ___(13)___ hair.

However, if the genes in a pair are different, then one gene will always be dominant or controlling. The gene for the dominant trait determines what the characteristic will be. The other trait does not show in the individual.

Brown eyes are always dominant over blue eyes. Therefore, an individual with one gene for brown eyes (B) and one gene for blue eyes (b) will have brown eyes. Both eyes will be brown.

In any unlike pair, the gene for the ___(14)___ (dominant/other) trait determines what the characteristic will be.

We usually use capital letters for the dominant trait. Look at this gene pair.

Sc

The S stands for straight hair and the c stands for curly hair. Since S is the capital letter, it is the dominant gene. The individual with this pair of genes will have ___(15)___ hair.

The gene for the dominant trait controls what trait will appear. The other trait does not show in the individual. This other trait is called the recessive trait.

Blue is recessive to brown eyes. If an individual has one gene for blue eyes and one gene for brown eyes, the blue will not show. There must always be two genes for blue eyes for the individual to have blue eyes.

A recessive trait does not show unless there are ___(16)___ genes for that same trait.

We use small letters for the recessive trait. Look at this pair.

Bb

The B stands for a gene for brown eyes and the b stands for a gene for blue eyes.

The B is the gene for the ___(17)___ (dominant/recessive) trait.

The b is the gene for the ___(18)___ (dominant/recessive) trait.

The individual's eye color will be ___(19)___.

Now you know that the gene patterns ___(20)___ and ___(21)___ both produce brown eyes, because brown (B) is dominant.

3

ANSWER SHEET

14. dominant	14. ______	1. heredity	1. ______
	7. like	7. ______	
15. straight	15. ______	2. genes	2. ______
	8. unlike	3. ______	
		3. genes	3. ______
	9. like	9. ______	
	10. unlike	10. ______	
	11. unlike	11. ______	
	12. like	12. ______	
16. two	16. ______	4. two	4. ______
	13. straight	13. ______	
17. dominant	17. ______	5. brown	5. ______
18. recessive	18. ______		
19. brown	19. ______	6. instructions	6. ______
20. BB	20. ____		
21. Bb	21. ____		

NAME ______________________

CLASS ______________________

DATE ______________________

IV. We call what an individual looks like, his phenotype. If an individual has brown eyes, his phenotype for eye color is brown.

If an individual has naturally curly hair, his ___(22)___ type for hair is curly.

We call the gene pattern of an individual his genotype. We have already used letters (<u>bb</u> or <u>Sc</u>) to represent an individual's <u>genotype</u> for a characteristic.

If an individual has brown eyes, we are not always sure of his genotype. Here are two examples.

One person has two identical genes for brown eyes (<u>BB</u>).

We would say he had the following phenotype and genotype:

Phenotype - <u>brown</u>
Genotype - <u>BB</u>

Another person has one gene for brown (B) eyes and one gene for blue eyes (b). Since brown is dominant over blue, this person will have brown eyes also.

His phenotype is ___(23)___.
His genotype is ___(24)___.

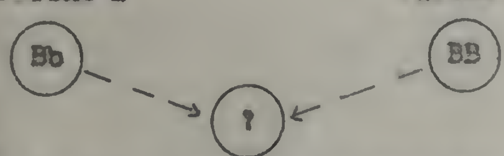
The gene pattern of an individual is called his <u>(25)</u> type. What the individual looks like is called his <u>(26)</u> type.

What is the genotype and phenotype of the following individuals:

	Genotype	Phenotype
someone with two genes for brown eyes,	(27)	brown
someone with one gene for brown eyes and one gene for blue eyes,	Bb	(28)
someone with two genes for blue eyes,	(29a)	(29b)

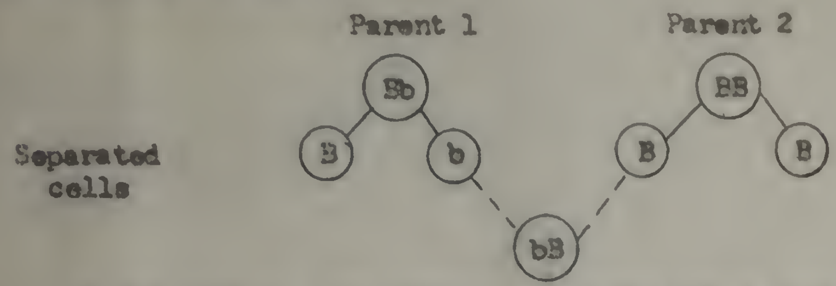
V. Now let's see what actually happens when a new individual is formed. Look at the following example:

Parent 1 Parent 2



We know that the new individual must have 2 genes for eye color too. The problem is which genes will he have.

When a new individual is formed, the gene pairs of the parent separate and each reproductive cell receives only one of the genes from the parent pair. Then the offspring receives only one of these genes from each parent. Taking one from each parent he has two genes altogether.



We can show all the possible combinations of genes in a box diagram. In the left are the two genes from Parent 1. On the top are the two genes from Parent 2.

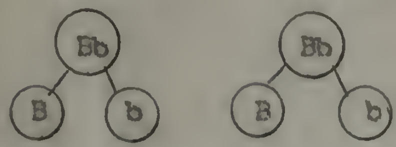
		Parent 2 B	B
Parent 1	B	BB	BB
	b	Bb	Bb

In the top row are the possible combinations if we take a large B from parent 1. In the bottom row are the possible combinations if we take a small b from parent 1. Some of the combinations are just alike. The only genotype possible in the top row is ____(30)____. The genotype possible in the bottom row is ____(31)____.

Since the uniting of cells occurs by chance, one cannot predict exactly which one of the possibilities will occur in a particular child. However, if we know the genotype of the parents, we know what is possible and impossible and we can predict about how many will have each genotype in a group of offspring from the same parents. In the cross between the BB parent and the Bb parent the four possible combinations were 2 BB and 2 Bb possibilities. Therefore about half of the offspring will be BB and the other half will be Bb. It is impossible for these parents to have a blue-eyed (bb) child because one of the parents has no small b gene to give to the offspring.

Now let's try a cross between two heterozygous parents. Look at the following charts.

Parent 1 Parent 2



The gene pairs of the parents separate and each reproductive cell has only one of the genes from the parent. The new individual is a combination of <u>one</u> gene from each parent.

Parent 2

		B	b
Parent 1	B	BB	Bb
	b	Bb	?

The fourth possible genotype combination would be ____(32)____.

How many of the four possible combinations would have <u>brown</u> eyes? ____(33)____.

We can see from this heterozygous cross, that both brown and blue-eyed offspring are possible, but the brown-eyed offspring will probably out-number the blue-eyed offspring.

ANSWER SHEET (cont.)

22. pheno — 22. ____________type

23. brown — 23. ____________

24. <u>Bb</u> — 24. ________

25. geno — 25. ____________type

26. pheno — 26. ____________type

32. <u>bb</u> — 32. __________

33. three — 33. __________

30. <u>BB</u> — 30. __________

31. <u>Bb</u> — 31. __________

27. <u>BB</u> brown — 27. __________ brown

28. Bb <u>brown</u> — 28. <u>Bb</u> ____________

29. <u>bb</u> <u>blue</u> — 29. ____ __________

Name ________________________________

REVIEW

A. On the top of your Review Answer Sheet is a list of words. Fill in each blank on your answer sheet with one of the words listed.

1. The units responsible for determining heredity of various characteristics are called ____(1)____.
2. The genes are best thought of as microscopic chemical ____(2)____.
3. If both genes for a single trait (such as eye color) are different, the pair of genes is said to be an ____(3)____ pair.
4. When a new living thing is formed there is chance uniting of ____(4)____ (how many?) genes.
5. What the individual looks like is called the ____(5)____ type.
6. The gene pattern of the individual is called the ____(6)____ type.
7. In the unlike gene pair, a trait that does <u>not</u> show in the phenotype is called ____(7)____.
8. In the unlike gene pair, the trait that shows in the phenotype is called ____(8)____.

B. In the following questions about hair straightness, straight hair (S) is dominant over curly (c) hair. A like dominant genotype for this trait would be shown as <u>SS</u>.

9. What is an unlike genotype for hair straightness? ____(9)____
10. A like genotype for the recessive trait would be ____(10)____.

In the next three questions, both parents in a family have unlike gene pairs for hair straightness.

Parent 2

Parent 1

	S	c
S	SS	
c		

11. What are the other possible combinations for their offspring? (Fill in the box on the answer sheet.)
12. Of the four possibilities in the box above, how many will be offspring with unlike gene pairs? ____(12)____.
13. How many will have straight hair? ____(13)____

In another family, one parent has like genes for the recessive trait (cc) and has curly hair, while the other parent has like genes for the dominant trait (SS) and has straight hair.

14. What are the four possible offspring?

	c	c
S		
S		

15. How many of these offspring will have straight hair? ____(15)____

Name ______________________________

Class ____________ Age ________

Date ________________________

Review Answer Sheet

A.

Phenotype	Genotype
Like	Unlike
Dominant	Recessive
Genes	One
Heredity	Two
Instructions	Three

1. ________________________

2. ________________________

3. ________________________

4. ________________________

5. ________________ type ___

6. ________________ type ___

7. ________________________

8. ________________________

B.

9. ______________

10. ______________

11.

	S	c
S	SS	
c		

12. ______________

13. ______________

14.

	c	c
S		
S		

15. ______________

APPENDIX II

Applicational Problem-Solving Test

Practice Problems.

We usually find out about the genes by working backwards from the traits that we can observe. Here is an example.

A girl has long eyelashes. Her parents and all her brothers and sisters have long eyelashes. She marries a boy with short eyelashes. His sister and both of his parents have short eyelashes. This couple has 6 children, all of whom have long eyelashes.

1. From this information, we can say that

   A. long lashes is the dominant trait;
   B. long lashes is the recessive trait;
   C. there is not enough evidence to know if long lashes is the dominant or recessive trait.

2. If we use a L (or l) for long lashes and an S (or s) for short eyelashes, the genotype of the mother of these 6 children might be

   A. SS　　B. Sl
   C. ll　　D. LL

3. Which one of the following box diagrams might illustrate this family?

A.

	S	L
L	LS	LL
L	LS	LL

B.

	s	s
L	Ls	Ls
L	Ls	Ls

C.

	L	s
L	LL	Ls
s	Ls	ss

Test Problems.

I. In cattle, a black coat (B) is dominant over red coat (b) and the hornless condition (H) is dominant over horned (h). A like gened, black horned male is mated with a like gened red, hornless female.

Pick one of these genotypes for each of the next thre questions.

A. bbhh
B. BBHH
C. BBhh
D. bbHH
E. BbHh

1. What is the genotype of the male parent?

2. What is the genotype of the female parent?

3. What are the possible genotypes of the offspring?

In mice, a rare gene for yellow (Y) coat is dominant over gray coat (y). Also a long tail (T) is dominant over a short tail (t). A yellow short-tailed male mouse with unlike genes for fur color is mated with a gray long-tailed male mouse with unlike genes for tail length.

Pick one of these answers for the next three questions.

A. Yytt
B. YyTt
C. yyTt
D. yytt

4. What is the genotype of the male parent?

5. What is the genotype of the female parent?

6. What are the possible genotypes for the offspring?

II. In a family history, squares are used to represent males and circles represent females.

Parents

Children

In this diagram, a blackened square or circle shows dark hair; a white square or circle shows blond hair.

7. These parents have

   A. two boys and two girls.
   B. three children.
   C. one boy and one girl.
   D. one boy and three girls.

8. Two of the children have dark hair. From this we can say that

   A. they inherited two genes for dark hair from their mother.
   B. they inherited one gene for dark hair from each parent.
   C. there is not enough evidence to know whether they have two genes or one gene for dark hair.
   D. they inherited two recessive genes.

9. From the evidence in this diagram

   A. blond hair is definitely recessive.
   B. blond hair is definitely dominant.
   C. there is not enough evidence to know whether blond hair is dominant or recessive.

This is another family history showing blond and dark hair inheritance. A blackened square or circle again shows dark hair; a white circle or square indicates blond hair.

Parents

Children

10. From this diagram, blond hair is

    A. definitely dominant.
    B. definitely recessive.
    C. unknown. We cannot tell from this diagram whether blond hair is dominant or recessive.

11. Using a large B for the dominant hair color, and a small b for the recessive hair color, the genotype of the blond child (number 2 in the diagram) is

    A. BB B. Bb C. bb D. unknown

12. The genotype of the female parent (number 1) is

    A. BB B. Bb C. bb D. unknown

III. This family history shows the inheritance of straight or curly tails in three generations of pigs. A black square or circle shows a pig who has a curly tail; a white square or circle shows a pig with a straight tail.

Grandparents

Parents

Offspring

For each of the following statements, mark the answer sheet with a

T for true if the statement is true and its truth is supported by the evidence given in the diagram;

F for false if the statement is contradicted by the evidence given in the diagram; or

U for unknown if there is no evidence for deciding whether the statement is true or false.

13. A curly tail is probably a dominant trait.

14. A curly tail is definitely recessive.

15. Pig number 1 has two like genes for straight tail.

16. Pig number 3 has unlike genes.

17. Pig number 4 has unlike genes.

18. If the pigs numbered 2 and 3 were crossed, then about $\frac{1}{2}$ of their offspring would show a curly tail.

IV. This family history shows the inheritance of long and short fur in three generations of dog breeding.

Grandparents

Parents

Offspring

A darkened square or circle shows long hair; a white one shows short hair. For each of the following statements mark your answer sheet with a

T for true,

F for false, or

U for unknown, if the evidence is insufficient

19. Long hair is dominant.

20. Long hair is more likely recessive.

21. Dog number 1 has unlike genes.

22. Dog number 2 has two like genes for long hair.

23. Dog number 3 has unlike genes.

24. If the cross between dog number 3 and 4 had produced many more offspring, there would be a greater chance of having some long hair.

Name ______________________

Class ______________________

Date ______________________

Group ______________________

ANSWER SHEET

Circle the correct answer. Put an X on your second choice answer.

Warm-up practice problem

1. A. B. C.
2. A. B. C. D.
3. A. B. C.

I. 1. A. B. C. D. E.

2. A. B. C. D. E.

3. A. B. C. D. E.

4. A. B. C. D. E.

5. A. B. C. D. E.

6. A. B. C. D. E.

II. 7. A. B. C. D.

8. A. B. C. D.

9. A. B. C.

10. A. B. C.

11. A. B. C. D.

12. A. B. C. D.

III. 13. T F U

14. T F U

15. T F U

16. T F U

17. T F U

18. T F U

IV. 19. T F U

20. T F U

21. T F U

22. T F U

23. T F U

24. T F U

APPENDIX III

Cohesion Scale

MY GROUP

FRIENDLY	:___:___:___:___:___:___:___:___:	UNFRIENDLY
UNHELPFUL	:___:___:___:___:___:___:___:___:	HELPFUL
ENTHUSIASTIC	:___:___:___:___:___:___:___:___:	UNETHUSIASTIC
LOTS-OF-FUN	:___:___:___:___:___:___:___:___:	SERIOUS
NON-PRODUCTIVE	:___:___:___:___:___:___:___:___:	PRODUCTIVE
CLOSE	:___:___:___:___:___:___:___:___:	DISTANT
COLD	:___:___:___:___:___:___:___:___:	WARM
COOPERATIVE	:___:___:___:___:___:___:___:___:	UNCOOPERATIVE
MEAN	:___:___:___:___:___:___:___:___:	KIND
BORING	:___:___:___:___:___:___:___:___:	INTERESTING
REJECTING	:___:___:___:___:___:___:___:___:	ACCEPTING
SUCCESSFUL	:___:___:___:___:___:___:___:___:	UNSUCCESSFUL

Would you pick these team members for your group in another problem task.

first choice	:___:___:___:___:___:___:___:___:	not under any conditions

APPENDIX IV

DIFFICULTY LEVEL OF PROBLEM SOLVING ITEMS FOR THE EXPERIMENTAL POPULATION

	Percent of Ss Responding Correctly (adjusted for chance)			
Item	0-19%	20-39%	40-59%	60-69%
1.			X	
2.			X	
3.			X	
4.			X	
5.			X	
6.	X			
7.				X
8.		X		
9.			X	
10.			X	
11.		X		
12.	X			
13.	X			
14.		X		
15.	X			
16.	X			
17.	X			
18.		X		
19.		X		
20.		X		
21.	X			
22.		X		
23.		X		
24.	X			

APPENDIX V

ANALYSIS OF VARIANCE OF THE

NUMBER OF CORRECT RESPONSES ON MEDIUM DIFFICULTY ITEMS

Source of Variance	d.f.	Mean Square	F
Total	274		
Grade	1	7.09	1.37
Achievement	1	327.34	63.97 ***
Instructions	2	35.55	6.95 **
Grade X Achieve	1	9.77	1.91
Grade X Instructions	2	29.19	5.71 **
Achieve X Instruct.	2	1.92	0.38
Grade X Achieve X Inst.	2	10.96	2.14
Error	262	5.12	

*** $p<.001$.

** $p<.005$.

APPENDIX VI

ANALYSIS OF VARIANCE OF THE

NUMBER OF CORRECT RESPONSES ON ITEMS IN THE FIRST HALF

OF THE APPLICATIONAL PROBLEM SOLVING TEST

Source of Variance	d.f.	Mean Square	F
Total	274		
Grade	1	13.67	3.31
Achievement	1	481.48	116.23 ***
Instructions	2	19.38	4.68 **
Grade X Achieve	1	2.20	0.53
Grade X Instructions	2	28.32	6.84 **
Achieve X Instructions	2	2.70	0.65
Grade X Achieve X Inst.	2	0.66	0.16
Error	262	4.14	

*** $p < .001$.

** $p < .01$.

APPENDIX VII

ANALYSIS OF VARIANCE OF THE

NUMBER OF CORRECT RESPONSES ON ITEMS IN THE SECOND HALF

OF THE APPLICATIONAL PROBLEM SOLVING TEST

Source of Variance	d.f.	Mean Square	F
Total	274		
Grade	1	4.32	1.04
Achievement	1	2.36	0.57
Instructions	2	7.49	1.81
Grade X Achievement	1	9.15	2.21
Grade X Instructions	2	3.92	0.95
Achieve X Instruct.	2	1.70	0.41
Grade X Achieve X Inst.	2	4.92	1.19
Error	262	4.15	

APPENDIX VIII

PRINCIPAL FACTOR ANALYSIS OF COHESION SCALE ITEMS

UNROTATED MATRIX

Items	Factor I	Factor II	Factor III	Factor IV
Friendly	0.701	-0.335	0.230	-0.058
Helpful	0.713	0.120	-0.341	-0.265
Enthusiastic	0.687	-0.031	-0.147	-0.223
Lots-of-fun	0.186	-0.369	-0.109	0.086
Productive	0.764	0.403	-0.004	0.146
Close	0.635	-0.324	-0.300	0.2[illegible]4
Warm	0.635	-0.352	-0.095	-0.137
Cooperative	0.817	0.232	0.033	-0.251
Kind	0.779	0.038	0.343	-0.035
Interesting	0.651	-0.263	0.348	-0.065
Accepting	0.740	0.042	0.205	0.308
Successful	0.712	0.434	-0.011	0.129
Chosen	0.737	-0.028	-0.279	0.158

Trace - 8.315

Sum of Squares	6.194	0.971	0.661	0.456
Percent of Communality	74.49	11.67	7.96	5.48
Cumulative Percent of Communality	74.49	86.16	94.12	99.60
Percent of Variance	47.65	7.46	5.09	3.51

APPENDIX IX

OBLIMIN ROTATION OF THE

PRINCIPAL FACTORS ANALYSIS OF COHESION SCALE ITEMS

Items	Factor I	Factor II
Friendly	0.257	0.557
Helpful	0.5[illegible]	0.134
Enthusiastic	0.463	0.266
Lots-of-fun	-0.130	0.411
Productive	0.825	-0.114
Close	0.219	0.523
Warm	0.211	0.556
Cooperative	0.741	0.065
Kind	0.577	0.234
Interesting	0.273	0.472
Accepting	0.552	0.216
Successful	0.810	-0.161
Chosen	0.500	0.281
Sum of Squares	3.583	1.596

*V Matrix--row vectors are original length